Sr-04-RC

STRONTIUM-90 IN WATER CONTAINING OTHER RADIOISOTOPES BY CERENKOV COUNTING

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APPLICATION

The following procedure is used in the EML Quality Assessment Program (QAP; Sanderson and Greenlaw, 1996) for water or gross alpha/beta samples containing ^{90}Sr. This procedure was developed by Jimmy Chang, Institute of Nuclear Energy Research, Taiwan, and was tested at EML using NIST ^{90}Sr/Y reference materials and ^{90}Sr contained in QAP water samples. It allows for the rapid determination of ^{90}Sr (β_{max} = 0.546 MeV) via its progeny, ^{90}Y (β_{max} = 2.27 MeV) in aqueous solutions by Cerenkov counting (see Procedure Ba-01-R; Scarpitta and Fisenne, 1996).

Cerenkov counting is applicable for β particles with maximum energies > 0.263 MeV. Alpha and gamma emitting nuclides are not detected. Immediately following separation of ^{90}Y from ^{90}Sr, a baseline count rate, C_b, is obtained to quantify any Cerenkov contribution by other nuclides that may be present in the sample.

Yield recovery is determined by adding 30 mg of Sr^{+2} carrier to the sample or by gamma counting the added ^{85}Sr tracer. The sample is Cerenkov counted at any two time intervals, t_1 and t_2, to measure the ingrowth of ^{90}Y above C_b. Strontium-90 is calculated from the ingrowth of ^{90}Y. The Cerenkov counting efficiency for ^{90}Y in water is about 65-70%, whereas that of ^{90}Sr is < 0.3% for a 0-15 keV Cerenkov counting window. For a 20-min count time, the detection limit is about 6 mBq mL^{-1} (0.16 pCi mL^{-1}) or 0.35 dpm mL^{-1} with a relative standard deviation < 3%.

SPECIAL APPARATUS

Packard Tri-Carb 2250-CA liquid scintillation spectrometer

SPECIAL REAGENTS

1. NIST traceable ^{90}Sr/Y reference standard of known activity (about 1000 dpm g^{-1}) to determine the ^{90}Y Cerenkov counting efficiency.

2. TRU Resin - Eichrom Industries, 8205 Cass Ave., Suite 107, Darien, IL 606651.

DETERMINATION

1. Dispense about 8-16 Bq of ^{90}Sr gravimetrically into either a 20 mL low ^{40}K borosilicate glass or plastic scintillation vial (see **Note 1**).

2. Add 10 mL of deionized water.

3. Prepare a blank using 10 mL of water.

4. Count both samples three times for 10-min each using the net average count rate to determine the ^{90}Y counting efficiency, E ^{90}Y (counts min^{-1} dpm^{-1}).

5. Preset the Packard Tri-Carb to Protocol 4 for Cerenkov determinations (Scarpitta and Fisenne, 1996). (**Note**: The Cerenkov counting window is typically 0-15 keV, although the full window, 0-2000 keV, may be used with a 50% increase in background.)

6. Obtain a sample containing an unknown amount of ^{90}Sr.

7. Add 30 mg of Sr^{++} carrier (as nitrate) to the sample for yield recovery.

8. Prepare an identical vial containing water as a Sr^{++} reference standard.

9. Reduce a premeasured amount, M_g (g), of sample to be tested to 10 mL to improve counting statistics.

Note :

1. A wavelength shifter, ANSA (7-Amino 1,3 Naphthalene di-Sulfonic Acid) can be used to enhance the Cerenkov counting efficiency but is not recommended if strontium yield recovery is to be determined gravimetrically. Nuclides that produce a Cerenkov signal in 25 mM ANSA are shown in Figure 1 (see Scarpitta and Fisenne, 1996).

SEPARATION

1. Separate the ^{90}Y from the ^{90}Sr by either oxalate precipitation (see Procedure Sr-03-RC) or EiChrom's TRU Spec extraction chromatographic resin. Record the separation date and time, t_o.

2. Obtain a net baseline count rate for C_b immediately following ^{90}Y separation, using Protocol No. 4 on the Packard Tri-Carb 2250 CA counter and the Cerenkov counting window (0-15 keV).

CALCULATIONS

1. Recount the ^{90}Sr fraction three times a day over a 2-day period using the count rates (counts min^{-1}) CT_1, CT_2 and CT_3 to calculate the ^{90}Sr activity in Step 2. The times t_1, t_2 and t_3 are the number of hours after ^{90}Y separation in Step 1 of **Separation.**

2. Use the ^{90}Sr calculation as follows when ^{89}Sr is not present in the sample. (**Note**: A Basic computer program is provided in the Appendix to perform the ^{90}Sr calculations.)

$$A_1 \ {}^{90}\mathrm{Sr}\left(\mathrm{Bq\ kg^{-1}}\right) = \frac{\left(CT_2 - CT_1\right) - C_b}{60 \text{ x } M_S \text{ x } E\ {}^{90}\mathrm{Y} \text{ x } \left[\exp\left\{-\lambda\left(t_1 - t_0\right)\right\} - \exp\left\{-\lambda\left(t_2 - t_0\right)\right\}\right]} \qquad (1)$$

$$A_2 \ {}^{90}\mathrm{Sr}\left(\mathrm{Bq\ kg^{-1}}\right) = \frac{\left(CT_3 - CT_1\right) - C_b}{60 \text{ x } M_S \text{ x } E\ {}^{90}\mathrm{Y} \text{ x } \left[\exp\left\{-\lambda\left(t_1 - t_0\right)\right\} - \exp\left\{-\lambda\left(t_3 - t_0\right)\right\}\right]} \qquad (2)$$

where:

λ = ^{90}Y decay constant - 0.01083 h^{-1}
E ^{90}Y = ^{90}Y Cerenkov counting efficiency (counts min^{-1} dpm^{-1})
M_s = mass of sample (kg)

3. Obtain the average of the two ^{90}Sr activity concentrations, A_1 and A_2 from Step 2. (**Note**: A third count could be obtained with Equation 2 if modified accordingly.)

4. Using the sample vial and the Sr^{+2} reference standard, precipitate the strontium as the carbonate, filter, dry and weigh each to obtain the yield recovery. Correct the value obtained in Step 3, dividing by the yield recovery factor. (**Note**: Gamma emitting ^{85}Sr can be added to the sample in Step 7 of **Determination** instead of Sr^{+2}.)

REFERENCES

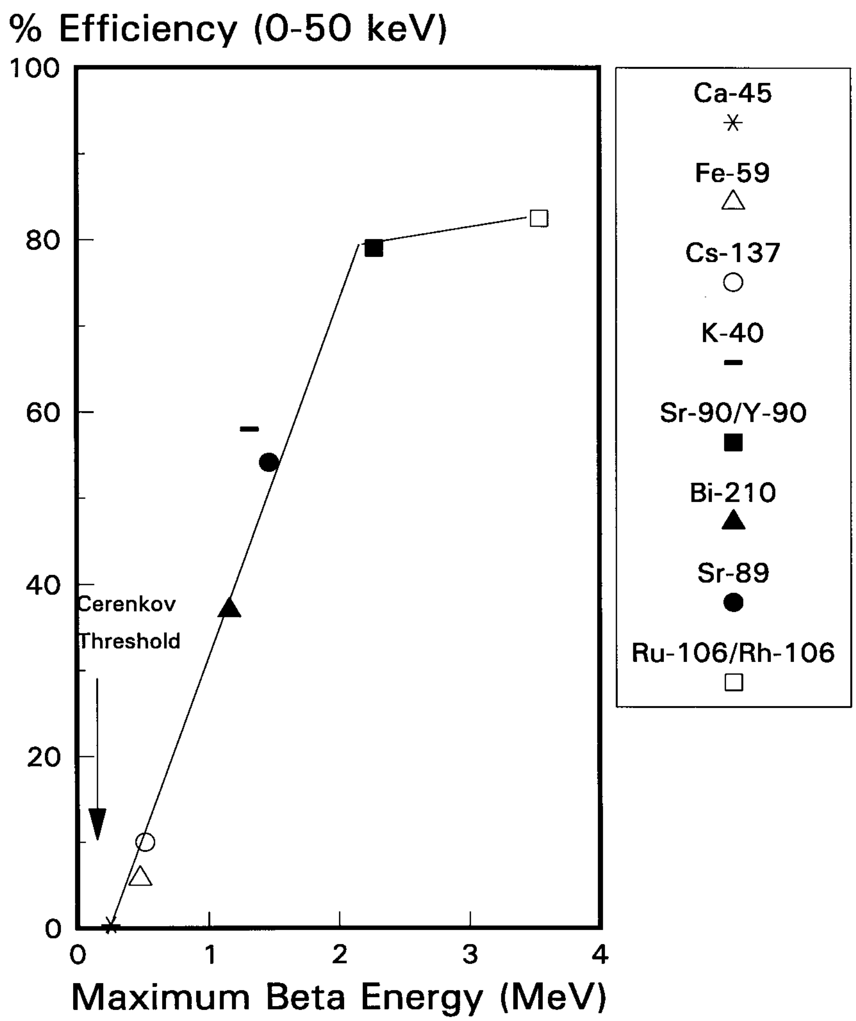
Sanderson, C. G. and P. Greenlaw
"Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program"
USDOE Report EML-581, July (1996)

Scarpitta, S. C. and I. M. Fisenne
"Cerenkov Counting as a Complement to Liquid Scintillation Counting"
Appl. Radiat. Isot., 47, 795-800 (1996)

Scarpitta, S. C. and I. M. Fisenne
"Calibration of a Liquid Scintillation Counter for Alpha, Beta and Cerenkov Counting"
USDOE Report EML-583, July (1996)

Cerenkov Efficiency in 10 ml of 25 mM ANSA

(Plastic Vials)



ANSA = 7-Amino 1,3 Naphthalene di-Sulfonic Acid

Figure 1. Cerenkov efficiency in 10 mL of 25 mM ANSA (plastic vials).

APPENDIX
Basic Computer Program

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10    REM "SR90CER.BAS" BY J.CHANG METHOD
20    REM CALCUlaTE 90SR ACTIVITY(DPM) FOR A SAMPLE USING CERENKOV COUNTING
50    TITLE$--"Test of Cerenkov Method Using  895 dpm of NIST 90-Sr Standard"
60    COUNTIME$="10 min"
100  REM ENTER TIME DATA HERE
120  DELTl=.75  '  HRS
122  DELT2=19.22
124  DELT3=111.6
130  REM ENTER COUNT RATES HERE
132  CT1=36.5
134  CT2 = 159.1
136  CT3=514. 4001
150  LAMBD2 = .01083 ' HR-1
160  EFFY90=.82 ' CPM/DPM
200  REM CALCULATE SR90 ACTIVITY(DPM) HERE
205  DF1 = EXP ((-LAMBD2*DELT1)) - EXP ((-LAMBD2*DELT2))
210  A1SR90 = (CT2-CT1) / (DF1*EFFY90)
255  DF2 = EXP ((-LAMBD2*DELT1)) - EXP ((-LAMBD2*DELT3))
260  A2SR90 = (CT3-CT1)/(DF2*EFFY90)
500  REM PRINT RESULTS
510  CLS : SCREEN 2 : KEY OFF
520  PRINT DATES;"      ";
525  PRINT "STRONTIUM-90 RESULTS BY Sr-SPEC and CERENKOV COUNTING" : PRINT
530  PRINT TAB(10);TITLE$ : PRINT
535  PRINT TAB (15); "Count Time = ";COUNTIME$; TAB (40) ;"Y-90 Effiency = ";EFFY90:
   PRINT : PRINT
540  PRINT "Data" : PRINT
550  PRINT TAB (1); "Del Ti" ;TAB (10); "Cnt Ti" ;TAB (30); "Del T2" ;TAB (40); "Cnt T2" ;TA (60) ;"Del T3" ;TAB (70);
"Cnt T3"
555  PRINT TAB (1);" (hr) ";TAB (10);" (cpm) ";TAB (30);" (hr) ";TAB (40);" (cpm) ";TAB (60); (hr) ";TAB(70);" (cpm)":
PRINT
557  PRINT TAB(l) ;DELT1;TAB(10) ;CT1;TAB(30) ;DELT2;TAB(40) ;CT2;TAB(60) ;DELT3;TAB( 0) ;CT3
560  PRINT : PRINT : PRINT :PRINT "Sr-90 Results";
570  PRINT TAB (30) ;A1SR90;" dpm" ;TAB(60) ;A2SR90;" dpm"
575  PRINT TAB(l) ;"Obs/Exp";TAB(30) ;A1SR90/895;" ";TAB(60) ;A2SR90/895;
580  PRINT : PRINT : PRINT
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02-21-1995     STRONTIUM-90 RESULTS BY Sr-SPEC and CERENKOV COUNTING

         Test of. Cerenkov Method Using 895 dpm of NIST 90-Sr Standard

                    Count Time -- 10 min             Y-90 Effiency -- .82

Data

Del T1        Cnt T1                    Del T2        Cnt T2                    Del T3        Cnt T3
(hr)          (cpm)                     (hr)          (cpm)                     (hr)          (cpm)

.75             36.5                    19.22         159.1                      111.6        514.4001

Sr-90 Results                           831.421 dpm                              840.6198 dpm
Obs/Exp                                 .928962                                  .9392401
Ok
```